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Aquatic Sensitivity to Acidic Inputs: Manitoba

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ABSTRACT

Maps illustrating Manitoba aquatic sensitivity to acidic inputs were developed using lake data for alkalinity, calcium and pH collected between 1977 and 1986.

It was found that waters highly sensitive to acidic deposition are located mainly in the National Topographic Sections (NTS) 64F and 64C. Some highly sensitive waters are also in NTS 63N and 63K. Medium sensitivity waters can be found in NTS 52L and 52M. The majority of water in the southern portion of Manitoba has low sensitivity. Detailed information for most of the northern area of Manitoba is not available.

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1.0 INTRODUCTION

The Province of Manitoba together with British Columbia, Alberta, Saskatchewan, the Northwest Territories and Canada made a commitment in December 1982, to coordinate research activities related to the long range transport of air pollutants (LRTAP) in Western Canada. The objectives of this coordinated effort included the identification of current conditions in Western Canada, and the gathering of necessary information to develop appropriate management strategies to address LRTAP issues (Western Canada LRTAP Technical Committee, Annual Reports, 1981, 1982, 1983, 1984, 1985, 1986).

This report deals with one of the program priorities established under this coordinated effort: the mapping of aquatic sensitivity to acidic deposition. Saskatchewan took the lead role in the aquatic sensitivity project by developing standards in conjunction with the other western provinces and in consultations with the eastern provinces. Environment Canada assisted by computer drawing preliminary sensitivity maps. Subsequently, each province reviewed these maps to ensure that they accurately reflected the existing provincial data. Discrepancies at the provincial borders were discussed and resolved through consultation with neighbouring provinces. Subsequently a report and aquatic sensitivity maps were prepared by each province and the Northwest Territories.

Water quality data collected between 1977 and 1986 were used to prepare Manitoba's aquatic sensitivity maps. During the tabulation of the Manitoba data, it became evident that large areas of the province had sparse water quality data. It would have not been practicable to fill the data gaps while waiting to produce the maps. Therefore, a decision was made to proceed on the basis of the existing data.

2.0 MAPPING LAKE SENSITIVITY

Sensitivity mapping is an important planning tool to identify resources at risk as a result of acidic deposition. Wotton and Halushak (1986) produced Manitoba sensitivity maps based on bedrock geology and soil type. This attempt was significant in that it provided a means of classifying wide areas of the Province without the need of detailed information. However, because of the diverse nature of Manitoba surface waters, aquatic sensitivity maps were a necessary complement to properly identify areas where aquatic resources, may be at risk.

2.1 GENERAL MAPPING CRITERIA

The basis of aquatic sensitivity mapping was the selection of the aquatic system (lake, river, stream) which accurately reflected the watershed. Because a lake ecosystem is intimately related to the surrounding land, it is considered to be an integrator of its watershed (Minnesota Pollution Control Agency, 1985). Chemical information from a lake reflects better the status of its watershed than chemical information from a river or stream while rivers and streams more accurately reflect recent events in a watershed, such as snow melt (Minnesota Pollution Control Agency, 1985). Also, an accurate representation of the water quality of a river or stream is not possible unless a large number of samples are taken in any one season (Minnsesota Pollution Control Agency, 1985). Therefore, the Co-ordinating Committee on surface waters, charged with the development of aquatic sensitivity maps in western and northern Canada, decided to base these maps on lake data only.

The following criteria were established by the Coordinating Committee on Surface Waters (Lechner and Howard, 1987):

- lake rather than river sensitivity should be mapped;
- discretionary use of river data could be made where appropriate coverage could not be derived from lake data, provided the data represents geochemically homogeneous watersheds;
- the parameters selected as basis for mapping should be alkalinity, calcium and pH;
- median values should be used for lakes with more than one measurement for a variety of depths, lake locations, seasons or periods in a season;
- only data collected since January 1977 should be used to ensure that recently developed analytical techniques will be utilized and to ensure the maps reflect present lake sensitivity;
- the maps should be drawn to a scale of 1:2,000,000.

2.2 LAKE CLASSIFICATION CRITERIA

A lake classification criteria for Western Canada was first developed by the Saskatchewan Research Council (1982) with input from the four Western provinces and Environment Canada. The three sensitivity classes chosen were: high, moderate and low sensitivity. These classes are defined by the parameter ranges using calcium and total alkalinity (Table 1).

Table 1: Ranges for lake classification criteria*

PARAMETERS	SENSITIVITY CLASS RANGES (mg/L)		
	HIGH	MODERATE	LOW
Calcium (Ca)	less than 4	4-8	greater than 8
Total Alkalinity ($CaCO_3$)	less than 10	10-20	greater than 20

*After Saskatchewan Research Council (1982).

3.0 MAPPING METHODOLOY

3.1 DATA COLLECTION

Information from approximately 6000 lakes was obtained and utilized to prepare the maps. The data were collected from various agencies including Manitoba Department of Environment - Environmental Management Services Branch, Manitoba Department of Natural Resources - Fisheries Branch and the Geochemical Reconnaissance Program operated by the Manitoba Department of Energy and Mines and the Geological Survey of Canada.

The parameters utilized in this study were calcium, alkalinity and pH from 1977 to 1986. The data were screened and apparent outliers that could not be verified were excluded. A Total of 5813 pH data, 5637 calcium data and 5605 total alkalinity data were used to prepare the aquatic sensitivity maps to acidic inputs.

3.2 MAPPING PROCEDURE

Data were tabulated and provided to Environment Canada to prepare the initial contour maps. A computer program, developed by the Canadian Department of Energy, Mines and Resources, was used for this purpose. Anomalies in the computer based maps were manually adjusted to fit the map scale (1:2,000,000). Individual maps for calcium and alkalinity were constructed. A composite map was produced by overlapping the calcium and alkalinity maps. This composite map provided information on the areas in Manitoba which were sensitive to both calcium and alkalinity.

A fourth map was made by plotting pH isopleths. There are no criteria to relate the pH of a lake to sensitivity. However, the probability of a lake to be affected at an early date by acidic deposition increases if the pH of the lake is below seven. Because of this fact the pH map was deemed to provide useful information in the context of the aquatic sensitivity mapping exercise.

4.0 RESULTS AND DISCUSSION

For this report the Province has been divided into three regions: South, North-Central and North according to Green and Derksen (1984). The regional boundaries are shown in Figure 1 together with the National Topographic Series (NTS) sections within each region. The percent of lakes sampled for pH, calcium and total alkalinity versus the total number of lakes in each of the three Manitoba regions are reported in Table 2. Lake Winnipeg, Lake Manitoba and Lake Winnipegosis have not been included since they straddle the South and the North-Central regions (Green and Derksen, 1984). These lakes are very large, covering a total surface area of 3.36×10^4 km^2 (Green and Derksen,1984). The available data for these lakes show that they are well buffered (Keleher, 1988) and can be classified as least sensitive to acidic precipitation.

Table 2 shows that most of the lakes sampled are in the North Central region and that the total sample coverage for Manitoba as a whole is approximately 10%. The data base seems sufficient to grossly estimate the aquatic sensitivity of Manitoba lakes. However, it does not provide information on data distribution within each region. This information is important to assess whether data gaps exists.

Tables 3, 4 and 5 provide the percent distribution of data by parameter within the NTS sections of each region.

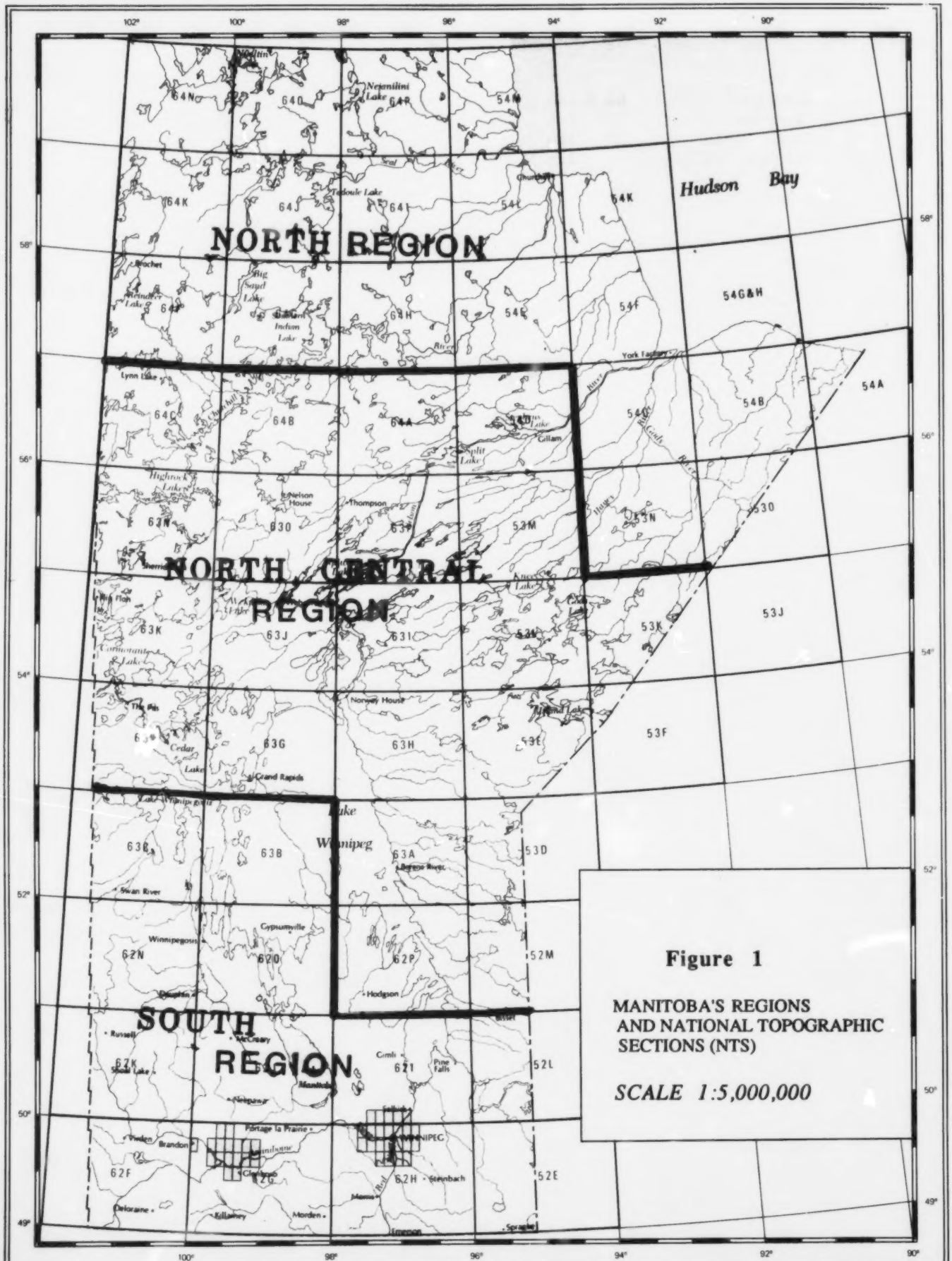
The South region, with the least amount of lake data as shown in Table 3, has the best data coverage in that data have been collected from most of NTS sections.

Table 2: Data coverage by parameter (pH, calcium and total alkalinity) within the three Manitoba regions.

	MANITOBA REGIONS			TOTAL FOR MANITOBA
	SOUTH	NORTH CENTRAL	NORTH	
TOTAL NUMBER OF LAKES(1)	3140	18536	33656	55332
DATA FOR:				
pH	6.9%	19.1%	6.1%	10.5%
Calcium	3.5%	18.8%	6.1%	10.2%
Total Alkalinity	2.9%	17.8%	6.1%	10.1%

NOTES: - Lake Winnipeg, Lake Manitoba and Lake Winnipegosis are not included in the calculations.

(1) After Green and Derksen (1984).


NORTH REGION
NORTH CENTRAL REGION
SOUTH REGION
Hudson Bay
Lake Winnipeg
WINNIPEG
64N
64O
64P
64K
64J
64I
54K
54G&H
64H
54E
54F
64F
64C
64B
64A
54B
54A
62N
63O
63P
53M
53N
53O
63K
63J
63I
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53J
63G
63H
53F
63C
63B
63A
53D
62N
62O
62P
52M
62K
62I
52L
62F
62G
62H
52E
Figure 1
MANITOBA'S REGIONS AND NATIONAL TOPOGRAPHIC SECTIONS (NTS)
SCALE 1:5,000,000

Table 3: Percent distribution of data by parameter (pH, calcium and total alkalinity) within the NTS sections of the South region.

NTS SECTION	DATA DISTRIBUTION (%)		
	pH	Ca	Total Alkalinity
52E	4.1	3.6	3.2
52L	19.3	25.3	26.9
62F	2.3	0.0	0.0
62G	7.3	1.8	3.2
62H	0.5	0.0	0.0
62I	3.2	1.8	2.2
62J	13.8	16.2	21.5
62K	33.0	45.9	36.5
62N	11.0	1.8	4.3
62O	1.8	2.7	2.2
63B	0.5	0.9	0.0
63C	3.2	0.0	0.0
Totals	100.0	100.0	100.0
TOTAL DATA BASE	218	111	93

NOTE: Lake Winnipeg, Lake Winnipegosis and Lake Manitoba are excluded from the percentages.

Table 4: Percent distribution of data by parameter (pH, calcium and total alkalinity) within the NTS sections of the North Central region.

NTS SECTION	DATA DISTRIBUTION (%)		
	pH	Ca	Total Alkalinity
52M	0.3	0.3	0.1
53D	0.3	0.3	0.3
53E	0.2	0.1	0.1
53F	0.0	0.0	0.0
53K	0.0	0.0	0.0
53L	0.2	0.1	0.1
53M	0.1	0.1	0.0
54D	0.2	0.0	0.0
62P	0.0	0.0	0.1
63A	0.1	0.1	0.0
63F	0.1	0.0	0.1
63G	0.1	0.0	0.0
63H	0.1	0.0	0.0
63I	0.1	0.1	0.1
63J	0.4	0.2	0.3
63K	15.5	14.9	15.0
63N	21.0	21.4	21.4
63O	6.9	7.0	6.9
63P	0.2	0.1	0.1
64A	0.1	0.0	0.0
64B	20.1	20.4	20.4
64C	34.0	34.9	35.0
Totals	100.0	100.0	100.0
TOTAL DATA BASE	3541	3478	3465

NOTE: Lake Winnipeg, Lake Winnipegosis and Lake Manitoba are excluded from the percentages.

Table 5: Percent distribution of data by parameter (pH, calcium and total alkalinity) within the NTS sections of the North region.

NTS SECTION	DATA DISTRIBUTION (%)		
	pH	Ca	Total Alkalinity
53N	0.0	0.0	0.0
53Ø	0.0	0.0	0.0
54A	0.0	0.0	0.0
54B	0.0	0.0	0.0
54C	0.0	0.0	0.0
54E	0.0	0.0	0.0
54F	0.0	0.0	0.0
54G	0.0	0.0	0.0
54K	0.0	0.0	0.0
54L	0.0	0.0	0.0
54M	0.0	0.0	0.0
64F	51.2	51.3	51.4
64G	48.6	48.7	48.6
64H	0.2	0.0	0.0
64I	0.0	0.0	0.0
64J	0.0	0.0	0.0
64K	0.0	0.0	0.0
64N	0.0	0.0	0.0
64Ø	0.0	0.0	0.0
64P	0.0	0.0	0.0
Totals	100.0	100.0	100.0
TOTAL DATA BASE	2054	2048	2047

The North Central region, with the largest amount of lake data as shown in Table 4, has excessive disparities insofar as data coverage. Only five NTS sections (63K, 63N, 63Ø, 64B and 64C) are very well covered out of 22. These are the NTS sections which were sampled through the Geochemical Reconnaissance Program.

The North region has the largest amount of lake data gaps as shown in Table 6. The data from this region are concentrated in two NTS sections (64G and 64G) out of a total of twenty. These data are derived from the Geochemical Reconnaissance Program. Unfortunately this is the region where the largest number of sensitive lakes may exist based on information from the soil Manitoba sensitivity maps (Wotton and Haluschak, 1986), the aquatic sensitivity maps for Saskatchewan (Lechner, 1987), and those for the Northwest Territories (Tibbatts and Gregor, 1987).

4.1 TOTAL ALKALINITY (Map No. 1)

The data base for total alkalinity covers a total of 5605 lakes. Table 6 summarizes the total alkalinity data by sensitivity class within the NTS section of the South region. Only three lakes of the 93 sampled have total alkalinity less than 10 mg/L. These lakes are in the NTS section 52L (Whiteshell area). The majority of lakes sampled in the region have total alkalinity greater than 20 mg/L and 15 have total alkalinity between 10 and 20 mg/L. Generally, the south region has low sensitivity to acid inputs with the exception of a small area in NTS sections 52L and 52E which can be classified as moderately sensitive.

Table 6: Distribution of total lake alkalinity data by sensitivity class within the NTS sections of the South region.

	SENSITIVITY CLASSES (units: mg/L of $CaCO_3$)		
NTS SECTION	Less than 10	10-20	Greater than 20
52E	ND	1	2
52L	3	9	13
62F	ND	ND	ND
62G	ND	ND	3
62H	ND	ND	ND
62I	ND	ND	2
62J	ND	2	18
62K	ND	1	33
62N	ND	2	2
62Ø	ND	ND	2
63B	ND	ND	ND
63C	ND	ND	ND
TOTALS	3	15	75

NOTE: "ND" means no data available

The distribution of total alkalinity by sensitivity class within the NTS sections of the North Central region is shown in Table 7. A total of 485 samples have alkalinity less than 10 mg/L. This represents 14% of all the samples. These lake data are mainly from three NTS sections (64C, 63N and 63K). Approximately 60% of the samples had total alkalinity greater than 20 mg/L as calcium carbonate. However, the results may be biased because approximately 98% of the samples were collected from 5 NTS sections (63K, 63N 630, 64B and 64C) out of 22.

The distribution of total alkalinity by sensitivity classes within the NTS section of the North region is reported in Table 8. Approximately 10% of the samples (211) had total alkalinity less than 10 mg/L as calcium carbonate. The number of samples in the other two sensitivity classes (10-20 mg/L and greater than 20 mg/L) are similar. Only data from NTS sections 64F and 64G are available, leaving the sensitivity for the remainder of the region unknown.

4.2 CALCIUM (Map No. 2)

The data base used in this report for calcium totals 5637 data. The distribution of lake calcium data by sensitivity class within the NTS sections of the South region is summarized in Table 9. Only 2 samples out of 111 collected are less than 4 mg/L. Most of the calcium results (84%) are greater than 8 mg/L. This means that South region is, generally, of low sensitivity as indicated by calcium concentration.

Table 7: Distribution of total lake alkalinity data by sensitivity class within the NTS sections of the North Central region.

NTS Section	SENSITIVITY CLASSES mg/L of $CaCO_3$ Less than 10	10-20	Greater than 20	NTS Section	SENSITIVITY CLASSES mg/L of $CaCO_3$ Less than 10	10-20	Greater than 20
52M	ND	ND	3	63G	ND	ND	1
53D	ND	8	2	63H	ND	ND	ND
53E	ND	ND	2	63I	ND	ND	3
53F	ND	ND	1	63J	ND	ND	10
53K	ND	ND	ND	63K	27	97	395
53L	ND	ND	3	63N	68	269	406
53M	ND	ND	1	63Ø	6	27	206
54D	ND	ND	ND	63P	ND	ND	3
62P	ND	ND	3	64A	ND	ND	1
63A	ND	ND	1	64B	2	18	686
63F	ND	ND	2	64C	382	473	359
SUB-TOTAL	ND	8	18	SUB-TOTAL	485	884	2070

TOTAL DISTRIBUTION BY SENSITIVITY CLASS

Less than 10	10-20	Greater than 20
485	892	2088

NOTE: "ND" means no data available

Table 8: Distribution of total lake alkalinity data by sensitivity class within the NTS sections of the North region.

NTS Section	SENSITIVITY CLASSES mg/L of $CaCO_3$ Less than 10	10-20	Greater than 20	NTS Section	SENSITIVITY CLASSES mg/L of $CaCO_3$ Less than 10	10-20	Greater than 20
53N	ND	ND	ND	54M	ND	ND	ND
53Ø	ND	ND	ND	64F	197	755	99
54A	ND	ND	ND	64G	14	172	809
54B	ND	ND	ND	64H	ND	ND	ND
54C	ND	ND	ND	64I	ND	ND	ND
54E	ND	ND	ND	64J	ND	ND	ND
54F	ND	ND	ND	64K	ND	ND	ND
54G	ND	ND	ND	64N	ND	ND	ND
54K	ND	ND	ND	64Ø	ND	ND	ND
54L	ND	ND	ND	64P	ND	1	ND
SUB-TOTAL	ND	ND	ND	SUB-TOTAL	211	928	908

TOTAL DISTRIBUTION BY SENSITIVITY CLASS

Less than 10	10-20	Greater than 20
211	928	908

NOTE: "ND" means no data available

Table 9: Distribution of lake calcium data by sensitivity class within the NTS section of the South region.

	SENSITIVITY CLASSES (units: mg/L of $CaCO_3$)		
NTS SECTION	Less than 4	4-8	Greater than 8
52E	ND	2	2
52L	1	13	14
62F	ND	ND	ND
62G	ND	ND	2
62H	ND	ND	ND
62I	ND	ND	2
62J	ND	1	17
62K	ND	ND	51
62N	1	ND	1
62Ø	ND	ND	3
63B	ND	ND	1
63C	ND	ND	ND
TOTALS	2	16	93

NOTE: "ND" means no data available

In the North Central region 22% of the calcium results are less than 4 mg/L, 29% are between 4 and 8 mg/L and the remainder are greater than 8, (Table 10). Although the sampling coverage is not uniform, and most of the data are from the NTS sections 63K, 63N, 64B and 64C, this region has sensitive areas and moderately senstive areas.

The distribution of the calcium data in the North region is shown in Table 11. Information is available for only two NTS sections, 64F and 64G. A total of 48% of the available data are less than 4 mg/l, indicating high sensitivity to acidic inputs. The situation in the remainder of the region is unknown.

4.3 pH (Map No. 4)

The data base used in this report for pH total 5813 data. The distribution of lake pH data by sensitivity class within the NTS sections of the South region is summarized in Table 12. None of the lakes sampled had pH less than 5 while 95% of the lakes sampled had a pH greater than 7. This confirms the previous information that the lakes sampled in the South region are well buffered. In the NTS section 52L, where the majority of low alkalinity samples were collected, only 2 lakes had a pH in the range of 6.0-6.9. The remaining 40 lakes sampled had pH greater than 7.0.

Within the North-Central region, five lakes out of 3541 in NTS sections 64B and 64C were found to have pH less than 5. The data distribution, is poor, since there are many gaps. The results are summarized in Table 13.

Table 10: Distribution of lake calcium data by sensitivity class within the NTS sections of the North Central region.

NTS Section	SENSITIVITY CLASSES mg/L of $CaCO_3$ Less than 4	4-8	Greater than 8	NTS Section	SENSITIVITY CLASSES mg/L of $CaCO_3$ Less than 4	4-8	Greater than 8
52M	ND	9	ND	63G	ND	ND	1
53D	ND	11	ND	63H	ND	ND	ND
53E	ND	ND	3	63I	ND	ND	4
53F	ND	ND	1	63J	ND	ND	8
53K	ND	ND	ND	63K	49	164	305
53L	ND	ND	2	63N	124	313	306
53M	ND	ND	2	63Ø	5	31	2.6
54D	ND	ND	1	63P	ND	ND	2
62P	ND	ND	ND	64A	ND	ND	1
63A	ND	4	ND	64B	6	48	657
63F	ND	ND	ND	64C	571	429	215
SUB-TOTAL	ND	24	9	SUB-TOTAL	755	985	1705

TOTAL DISTRIBUTION BY SENSITIVITY CLASS

Less than 4	4-8	Greater than 8
755	1009	1714

NOTE: "ND" means no data available

Table 11: Distribution of lake calcium data by sensitivity class within the NTS sections of the North region.

NTS Section	SENSITIVITY CLASSES mg/L of $CaCO_3$ Less than 4	4-8	Greater than 8	NTS Section	SENSITIVITY CLASSES mg/L of $CaCO_3$ Less than 4	4-8	Greater than 8
53N	ND	ND	1	54M	ND	ND	ND
53Ø	ND	ND	ND	64F	912	104	35
54A	ND	ND	ND	64G	74	223	699
54B	ND	ND	ND	64H	ND	ND	3
54C	ND	ND	ND	64I	ND	ND	ND
54E	ND	ND	ND	64J	ND	ND	ND
54F	ND	ND	ND	64K	ND	ND	ND
54G	ND	ND	ND	64N	ND	ND	ND
54K	ND	ND	ND	64Ø	ND	ND	ND
54L	ND	ND	ND	64P	ND	ND	ND
SUB-TOTAL	ND	ND	1	SUB-TOTAL	986	327	734

TOTAL DISTRIBUTION BY SENSITIVITY CLASS

Less than 4	4-8	Greater than 8
986	327	735

NOTE: "ND" means no data available

Table 12: Distribution of lake pH data by ranges within the NTS sections of the South region

	pH RANGES			
NTS SECTION	L5	5.0-5.9	6.0-6.9	G7.0
52E	ND	ND	3	6
52L	ND	ND	2	40
62F	ND	ND	ND	5
62G	ND	ND	ND	16
62H	ND	ND	ND	1
62I	ND	ND	ND	7
62J	ND	ND	2	28
62K	ND	ND	4	68
62N	ND	ND	ND	24
62Ø	ND	ND	ND	4
63B	ND	ND	ND	1
63C	ND	ND	ND	7
TOTAL	ND	ND	11	207

NOTE: "ND" means no data available

LEGEND: L stands for: less than
G stands for: greater than

Table 13: Distribution of lake pH data by ranges within the NTS sections of the North Central region

	pH RANGES			
NTS SECTION	L5	5.0-5.9	6.0-6.9	G7.0
52M	ND	ND	1	8
53D	ND	ND	6	4
53E	ND	ND	ND	6
53F	ND	ND	ND	1
53K	ND	ND	ND	5
53L	ND	ND	ND	7
53M	ND	ND	ND	2
54D	ND	ND	ND	1
62P	ND	ND	ND	ND
63A	ND	ND	ND	2
63F	ND	ND	ND	2
63G	ND	ND	ND	3
63H	ND	ND	ND	2
63I	ND	ND	ND	4
63J	ND	ND	ND	13
63K	ND	5	70	473
63N	ND	2	118	625
63O	ND	ND	9	234
63P	ND	ND	ND	7
64A	ND	ND	ND	2
64B	1	ND	4	706
64C	4	19	614	581
TOTAL	5	26	822	2688

NOTE: "ND" means no data available

LEGEND: L stands for: less than
G stands for: greater than

The North region is again the area where most of the data gaps exist. Information in this region is limited to 2 NTS sections (64F and 64G). Only 2 lakes out of 2054 sampled pH have a pH less than 5. The results are summarized in Table 14.

4.4 SENSITIVITY MAPS

Sensitivity maps based on total alkalinity (Map No. 1), calcium (Map No. 2) and combined calcium and total alkalinity (Map No. 3) indicated that highly sensitive areas are present in NTS sections 64F, 64G and 64C. Moderately sensitive areas are found in NTS sections 64B, 52L and 52M.

Data gaps exist, especially within the North and North Central regions. In these areas, only extrapolations can be made based on the maps prepared by Saskatchewan and the Northwest Territories.

Table 14: Distribution of lake pH data by ranges within the NTS sections of the North region

	pH RANGES			
NTS SECTION	L5	5.0-5.9	6.0-6.9	G7.0
53N	ND	ND	ND	1
53Ø	ND	ND	ND	ND
54A	ND	ND	ND	ND
54B	ND	ND	ND	ND
54C	ND	ND	ND	ND
54E	ND	ND	ND	ND
54F	ND	ND	ND	ND
54G	ND	ND	ND	ND
54K	ND	ND	ND	ND
54L	ND	ND	ND	ND
54M	ND	ND	ND	ND
64F	1	12	377	661
64G	1	2	47	947
64H	ND	ND	ND	4
64I	ND	ND	ND	ND
64J	ND	ND	ND	ND
64K	ND	ND	ND	ND
64N	ND	ND	ND	ND
64Ø	ND	ND	ND	ND
64P	ND	ND	ND	1
TOTAL	2	14	424	1614

NOTE: "ND" means no data available

LEGEND: L stands for: less than
G stands for: greater than

5.0 CONCLUSION

Based on the criteria developed by the Co-ordinating Committee on Surface Waters, highly sensitive waters were found in the north west corner of the North-Central region and in the south west corner of the North region. For most of the North region there are no data, therefore, only extrapolations can be made based on the aquatic senstivity maps of Saskatchewan and the Northwest Territories.

Moderately sensitive waters were found mostly east of Lake Winnipeg in the south east corner of the North-Central region and in the north east corner of the South region.

Low sensitive waters were found mostly in the South region and in the central part of the North-Central region.

Lake with pH less than seven were found mostly in the north west part of the North-Central region. Waters in the remaining portions of the province for which data are available is well buffered against the effects of acidic deposition.

The findings are a first effort, based on limited data. For most of the North region there were virtually no data. The South region has data base that covers the area well.

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